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ScienceDirect

Procedia Technology 9 (2013) 1005 – 1015

Procedia Technology

CENTERIS 2013 - Conference on ENTERprise Information Systems / PRojMAN 2013 - International Conference on Project MANagement / HCIST 2013 - International Conference on Health and Social Care Information Systems and Technologies

Redesigning Work– From Sedentariness to Activeness

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Abstract

At the core of 'Healthcare Information Systems' is an idea of designing systems that are functional, practical and contained integrated solutions. As humans have always spent the majority of their hours in seated positions in work environments and workplaces, it is important to investigate these environments before applying a design for promoting daily movement and physical activity. In this paper we focus on the history of workplace design. We argue that the strategies for reaching this sedentary living style have been carried out by different means during the past 70 years of technological development. Further on, we illustrate this current paradigm through the presentation of an empirical study that shows how people compensate for a passive mode of working. In this paper, we contribute to the current development in our field by offering this alternative design paradigm and we suggest concept-driven design research as a possible way forward if we are to design information systems for active worklife.

Keywords: Prolonged Sittting, Information Systems, Workplace Design, Concept-Driven Design Research.

1. Introduction

Current public health recommendation for increasing movement in daily lives and assigning certain hours

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doi:10.1016/j.protcy.2013.12.112

per week for physical activity is the focus of many Information Systems (IS) and as obesity is becoming a major consequence in public health these systems are expected to be designed more practical and functional. According to studies, prolong sitting is a risk factor in increasing all-cause mortality including cardiovascular disease (CVD), certain types of cancer and non-CVD/noncancer mortality in adults [8,16,23,26]. Prolong sitting contains all type of sedentary behaviours which incur no more than 1.5 metabolic equivalents and include sitting and lying down in all conditions of working, eating, transporting, among others [26]. Time spent sitting is associated with greater food consumption and therefore gaining weight especially while watching TV [8, 23]. The majority of us have been adopted to a lifestyle were we are seated most of the time during our work, while eating our meals, when we are commuting and while resting and watching TV in our leisure time therefore sitting is becoming to our main activity at work, school and home. Sometime we compensate our frequent setting in one domain by less sitting in another [26], or by exercising after work [26] but high amount of sitting hours cannot be compensated by occasional physical activity even if the amount reaches the current recommendations available by public health organizations [16].

Over the past century, due to the technological development, there has been a decrease in total daily energy expenditure [23]. It is recognized that the technological advances in workplace design have gradually reduced physical activity and therefore with the increased time spent sitting and higher calorie intake there has been a rise in obesity and temporal trends in cardiovascular disease, type2 diabetes and some cancer [23]. And therefore public health messages and guidelines should not only focus in promoting physical activity and daily movement, but also in ways to reduce sitting time [16,23]. Information systems could be used in an effective way to encourage people to shorten their sitting hours and motivate them to be more active during day. One of the best ways of having an effective design is to have a deep understanding of the situation and going through the history to see how humans adopted to the current sedentary lifestyle. As humans spent more than one third of their hours at work, in this paper we will dig through the history of sedentariness in workplace design to see how workplaces have been design during the past 70 years. First we illustrate how "sedentariness" has operated as a guiding concept throughout an 80-year long history of workplace design. This includes a review of Taylorism, ergonomics and in more general terms labor-economics [1,2,10]. While these movements did *increase productivity* our aim is to illustrate how it simultaneously was built upon a philosophy of optimizing for *elimination of individual movements* [6,7,11]. We illustrate how that guided design of digital assistants, agent-based paradigms for IT design, and ideas of computer-aided automation [17,29].

In section 3 we illustrate the consequences of workplace design optimized for work but not necessarily for movements through the presentation of an empirical study. In the presentation of this study we illustrate how people distribute hours of sports activities in relation to work hours. Our study demonstrates how people compensate for inactivity throughout the workday by going exercising before, in-between and directly after work hours. But still these limited hours of exercise cannot compensate the prolonged sitting hours. Based on existing research on NEAT – Non-Exercise Activities Thermogenesis [19,20] we move forward arguing that we need to re-think the nature of work being carried out. We conclude the paper with this standpoint as a point of departure for re-thinking workplace design and IT support for digital living.

2. Digging through the History of Sedentariness in Workplace Design

Throughout human history, there has been a tendency to aspire to design artifacts to promote the sedentary human being. Although, this trend was not aimed for making human seated from the beginning, but gradually it effected in how we design work and workplace. By entering the age of industrialization, new methods and theories were offered in order to carry out work in relation to economic efficiency and labor productivity. These theories such as Taylorism and methods similar to ergonomics altered the design of work and workplace in optimizing for minimal movement throughout a working day [2,6,7,11].

By introducing Taylor's scientific management [2,10], the organization of factory production assembly lines

was optimized to support mass production. Time and motion studies analyzed work, splitting it into simpler, faster components that resulted in deskilling and reskilling of the labor force. It started the whole debate on the effects of automation and work reorganization. There were those who took the side of capitalists, who saw deskilling as the natural outcome of adopting new technologies in the pursuit of profit; others felt that there was a natural tendency of the workforce to lose skills over time, with or without the introduction of new technologies [1,10].

During the Second World War, the field of ergonomics was invented, with the aim of improving human performance. Ergonomics dealt with the human at work from a number of perspectives such as psychology, physiology, engineering, behavioral sciences and so on. However, the definition of "ergonomics" is to consider "the customs, habits or laws of work". It was described as a need for the scientific study of humans and their work [24] and dealt with not only physical and psychological aspects of the work environment but also the interactions between human and machine. According to Shephard [24], humans were studied in their working environment and an attempt made to fit the job to that working environment. Work management and work analysis were the main objectives of ergonomics at this time. The main aims of designs were to increase performance and reduce stress and other disturbances while working [6,24].

By using the theory of scientific management in studies related to the performance of work, scientists in the 1980s started to undertake time and motion studies to examine all phases of the operation. Some researchers believed that repetitive work patterns could cause stress and be distracting and create the risk of fatigue, which could be dangerous [6,7,24]. In this section, we will briefly describe 80 years of workplace design and how these designs not only endured in workplaces and on factory production lines but were also transformed into modern techniques for collaborative work and technological designs for entertainment and leisure.

2.1 Workplace Design Over the Last 80 Years

In the 1980s and 1990s, with the introduction of ICT in workplaces, ergonomics scientists started to plan the layout of the workplace. These layouts resulted in good postural support, proper distribution of body weight and correct posture, ensuring that there was a minimal need to use a person's maximum reach or strength [7]. The design objective seemed plausible and, most of the time, the motion studied could be broken down into basic actions.

Maynard classified motion into five general classes [7]:

- Fingers
- Fingers and wrist
- Fingers, wrist and forearm
- Fingers, wrist, forearm and upper arm
- Fingers, wrist, forearm, upper arm and body

It was in the 1930s that the first attempts were made to study work in order to find more efficient and simpler ways of completing a job [2]. For designing the ideal work method, the study of both time and motion was seen as the most important technique. Motion study, or method design, dealt with finding the ideal method of performing a task, whereas time study and work measurement determined the standard to which that task should be carried out. These new methods were not only used for factory labor, but also for office work, an area where the numbers of workers was increasing at that time. According to Taylor's own time study, all work tasks should be split into basic movements, with unnecessary movements removed [2,7,29].

After Taylor, researchers started to analyze the work process in order to improve it. In these analyses, they investigated each step and, as a result, they developed process charts as a way to record the process concisely so as to better understand and improve it. Developing and analyzing these charts, researchers improved production methods such that the same product could be made with less walking and moving of the workers involved. There are many examples of working environments that have been redesigned to reduce the amount of walking by workers to zero, thus confining them to a single spot as they work [24].

The idea of "Scientific Management" was not only used by industry but was also applied to consumer goods such as kitchen appliances. Gilbreth's "Twelve Principles of Scientific Management" [5] described how to run a home more efficiently, more cheaply, with no servants. One of its suggestions was to put commonly-used equipment close to each other and make kitchens smaller, thus *reducing the movement required to accomplish tasks*. Reducing movement and simplifying tasks were all seen as ways of saving time and effort.

When designing work activities, it was suggested that the designs should be based on human requirements. From the ergonomics perspective, this design was intended to improve work postures related to well-being and the effective performance of people [7]. According to Corlett, "*posture is not just the orientation of the limbs in space, but includes muscular forces produced and the times for which they are held"* [6].

2.2 IT Applied in Workplaces – Setting at the Core

Although the invention of the first general-purpose electronic computer turned electrons into meaningful particles, digital living had not started by the late 1980s and early 1990s, when desktop computers entered our workplaces and our homes. These inventions were followed by the introduction of the Internet, which had a great effect on our personal and social lives. Being influenced from theories in relation to workplace design, new strategies for reaching this goal have included: a *tool-view* of the computer (making tasks easier to carry out), digital *agents and assistants* (making the computer do the work for us) and in designing *technology to bridge distances* (so as to free the user from the need to travel).

By the end of the 20th century, the role of IT in production and coordination of data in organizations became vital. Therefore, there was a need to integrate computer-based applications with production systems, resulting in applications such as "Computer Integrated Manufacturing" (CIM), "Computer Aided Design"(CAD) and "Computer Aided Manufacturing" (CAM). In fact, many of these applications are designed and implemented to reduce the need for labor so they are associated with changes in the way work is organized. As an example, the development of the technology in "cut and strip" wire-processing machines brought major changes to how the task is performed by operators, who required different skills and abilities. In some cases, in the final assembly areas, the operators had fragmented and simplified tasks to carry out from a fixed workstation [1].

In general, these developments brought significant changes in the roles of both operators and supervisors. An operator's tasks became more routine, simplified and involved less complexity, whereas supervisors required more understanding of the overall product in order to make good managerial decisions [1]. Moreover, the measurement of Taylor's ideas of time and motion changed. There were no longer managers with stopwatches, walking around the workplace; workers were now continuously monitored, almost to the microsecond, in an electronic office. Gradually, by introducing computers into the workplace, significant changes occurred. For example, even the management of farms and factories are now mostly supported by computer systems located in offices; the majority of the work force are now white-collar workers who handle these systems [17,29].

With the new versions of desktop computers in the 1980s, the computer became ubiquitous not only in the workplace but also in the home. With the introduction of the Internet, Computer Supported Cooperative Work (CSCW) became the modern way of working, where technical development was complemented by perspectives from anthropology and sociology related to human activities. There was a turn towards social networking where isolated, single person, single computers were no longer the emphasis. Moreover, other technological developments such as video-conferencing, videophones, online chat rooms as well as SMS and MMS using mobile phones all contributed to CSCW. Following these inventions, different ways for characterizing technology supported work were debated, such as defining where and when things occur in a virtual environment [3]. Academic research emphasized how these technological developments such as video-conferencing can enhance and extend this space [18].

Globalization and the increase in opportunities for social networking across the globe – enabled by the

Internet, digital services, and more lightweight computers and mobile phones triggered a discussion about the concept of a "global village" and researchers became interested in remote interaction, issues of presence and awareness and mobility [28]. The global village advanced the idea of "anytime, anywhere" work, that is, distributed and co-located work with mobility studies focused on work on the move [28]. Although CSCW, the global village and mobility were new, inspiring forms of defining work in their own right, each one of them, on their own, could not bring about fundamental change in the work environment. Although the use of video for CSCW limited individual physical space, with reduced degrees of freedom and inflexible interaction management [18], there were some limitations of the vision of anytime, anywhere. Some work depends on a specific time frame and place. However, in general, these ideas made people aware of the possibility of becoming "semi-virtual" and retaining their traditional face-to-face meetings [28].

Later on, researchers started to imagine a world where activities were ever increasingly delegated to agents. Agents are active computer processes that can communicate with other people or agents and could adapt their behavior [3]. They would work like talking heads, attending meetings, organizing diaries and guiding us through the large information space of modern life. However, developing such complex systems is very slow but, as an example, there are some applications that have an agent-based interaction, such as natural language processing. Still, the agent based agenda of computing came with an assumption of the active computer in support of the less active human.

3. Method & Research Site

As it was mentioned before it is estimated that inactive lifestyle is accounted for 6% of global deaths. According to The World Health Organization at least 150 minutes of moderate intensity exercise per week will reduce the risk of chronic disease including cardiovascular disease, type 2 diabetes mellitus and certain cancers [26]. Other recommendations from American Heart Association and the American College of Sports Medicine includes 30 minutes of moderate exercise or 20 minutes of vigorous exercise per week.

In the following and in order to reach a better understanding of how people compensate for their sedentary life and the various things they do to make their lives more active, we have gathered data from one of the biggest sports clubs in Europe. The aim of this study is to understand what times of day are the busiest and how long these exercise sessions last and to see even among those that are a member of this sport facility, will this exercise sessions compensate their prolonged sitting positions during work hours. The data were gathered from 04.06.2012 until midday on 12.04.2013 from the computer systems available to users to book classes or retrospectively store their training data. There are three ways of recording data: entering the data manually at the club, through the main website or by using a smartphone app.

These data contain a total of 119,230 logs, the majority (84.8%) of which were collected via the main website. 9.7% of people entered data manually with 5.0% using the smartphone app. The data belong to 2,226 different users with a mean of 53.5624 and a median of 35 logs over the time examined. The largest number of logs for a single user is 840 whereas the smallest is only one log.

Note that the present system allows the user to enter data not only for booking sessions but also data about previous sessions. Although the majority of the 97.7% of the data represent ongoing exercise regimes, there are historical data that have been added to the system. In total, these data span 1,389 days, from 01.01.2008 to 12.04.2013. The day with the most logs is 12.11.2012 with 637 logs. In the following, there is more analysis of this dataset examining when users normally visit the club and how much they exercise daily. Note that these analyses have been carried out using 'Data Desk 6.3' software.

a. Time Span

As was mentioned previously, we have adopted a passive lifestyle that has been forced on us for different reasons. Still, as workers in such environments we have learned to compensate for this inactivity by going to sports facilities.

In Fig 1, we can see that there is activity in this particular sports club across most hours of the day with the busiest times generally being from 4 p.m. to 6 p.m. However, it is noticeable that from 11 a.m. and 12 noon there is a considerable increase in visitors to sports clubs. This figure reflects that people are in fact bound to their work places during work hours and how they seek to compensate for inactivity by being active early in the morning before work, during their lunch hour and, mostly, after work. We can assume bodily inactivity during work hours. Otherwise, if they were already exhausted from work they would probably do other things in between work hours than go exercising. The figure also illustrates how our day has been split up in two by inactive working hours and the remaining time that we might spend on sport clubs.

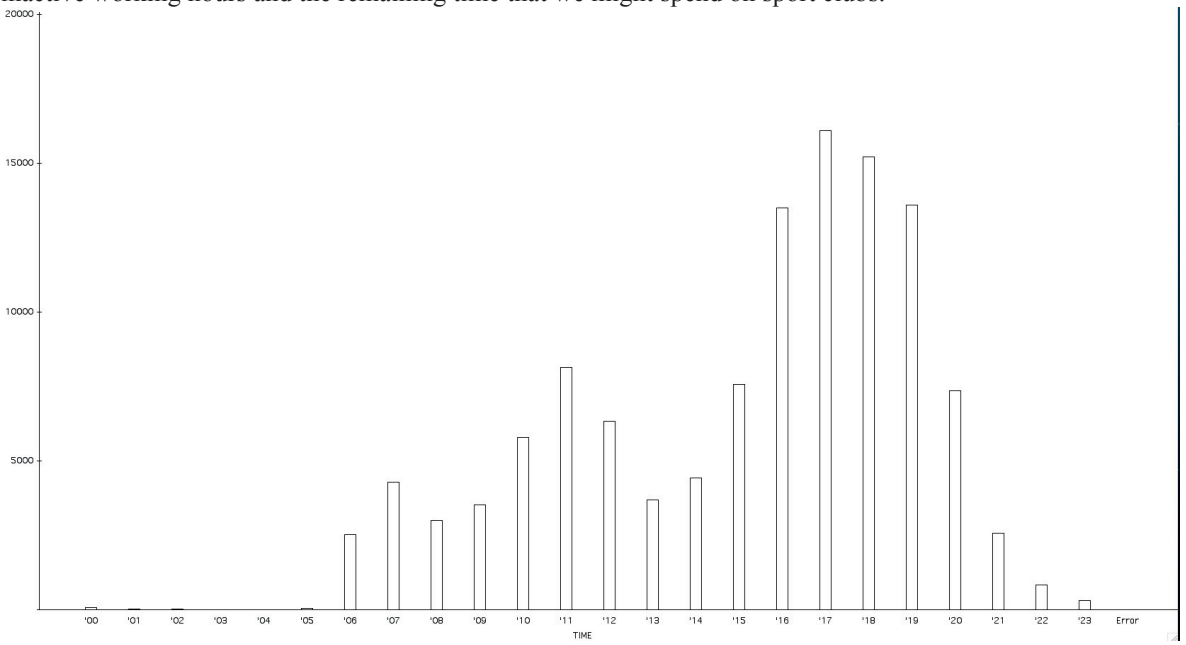
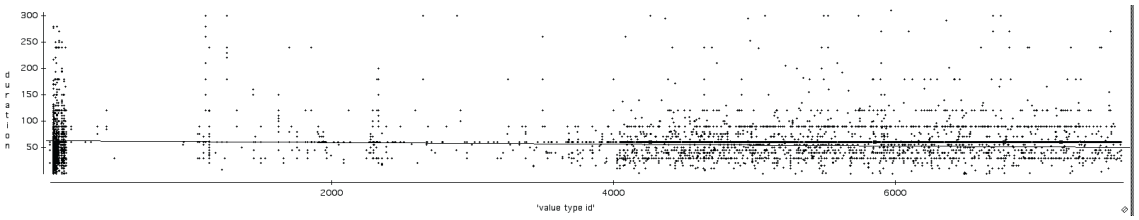


Fig 1. The time span of users attending gym by hour



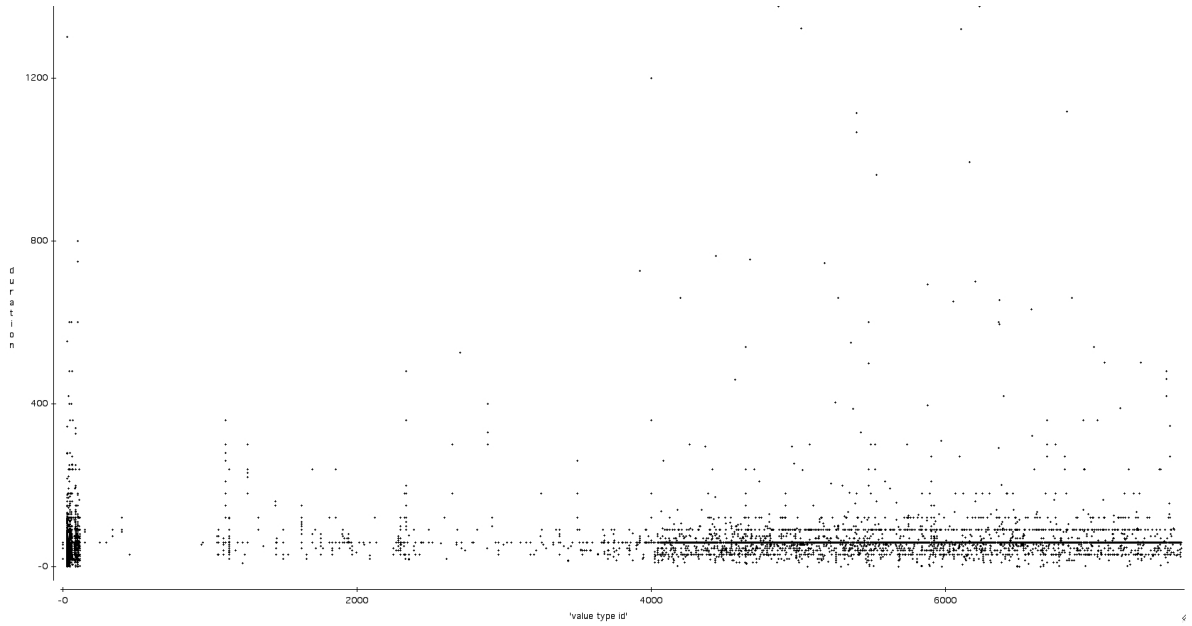


Fig 2. Scatterplot of the duration of each exercise. Each type of exercise is identified with an id called 'value type id'. In the y-axis the duration of each exercise is shown in minutes.

b. Duration

As shown in Fig 1, users mostly try to exercise in the afternoon. Of interest is the duration of these exercises and that they try to compensate for a passive worklife. According to our data gathered, the mean of users' daily activity is 62.3290 minutes with a median of 60 minutes. Fig 2 shows a scatter plot of the duration of the activity in relation to the activity that was chosen by the user. These activities have been given different codes by the system as 'value type id'. For better understanding the data in the scatterplot there is a regression line provided to illustrate the mean duration of the exercises in minutes. The following table also shows the mean of the duration of exercise for each hour. Morning sessions at 7 a.m. have the least duration, being 40 minutes long, but sessions starting at 9 a.m. last longer.

In Table.1 there is detail information about the number of logs and the duration of the exercise accomplished hourly. From the comparison of the numbers we can see that the most number of logs belongs to 17 pm in the afternoon with the median of 55 minutes long exercise. It is interesting to see that the number of users exercising in 7 am, suddenly doubles. The median time for actively exercising in this hour is 40 min that is the lowest time. The reason could relay on how users try to reach their work by 8 am.

By considering the numbers and figures, we can see that during the period between 04.06.2012 until midday on 12.04.2013 in median each user logged in 35 times and considering the mean time of their physical activity per session which is 62.3290 minutes, each user had exercised less than a third of the recommended figure of 150 minutes per week. In this data set, which is approximately 44 weeks, they have exercised 2181.515 minutes, which make 49.6 minutes weekly. This data explicitly states that most people fail in compensating their prolonged setting hours by attending sport clubs therefore, one way for making people more active is to redesign the workplace in a way to reduce setting hours.

Table 1 – Detail information of the logs and mean and median duration of exercise accomplished in each hour.

Summary of duration
For categories in Year 1
No Selector
119230 total cases of which 3 are missing

Group	Count	Mean	Median	StdDev
‘00	95	59.2000	60	65.0209
‘01	41	85.1463	60	195.092
‘02	41	62.0488	60	23.6082
‘03	21	51.4286	60	13.5225
‘04	10	85.5000	90	14.2302
‘05	58	57.2453	55	21.4979
‘06	2531	70.9689	90	24.4341
‘07	4288	52.6071	40	27.2745
‘08	3005	68.4128	60	46.2494
‘09	3546	72.2840	60	54.6891
‘10	5793	66.2350	60	36.3323
‘11	8154	61.3649	60	34.9002
‘12	6352	61.6632	55	25.5163
‘13	3703	73.3005	90	30.3658
‘14	4448	72.4190	90	25.1976
‘15	7573	63.3853	60	25.6402
‘16	13507	60.5255	60	24.6031
‘17	16110	59.1163	55	23.1279
‘18	15233	59.6243	55	21.4560
‘19	13613	59.5029	55	22.6514
‘20	7370	62.6327	55	27.6973
‘21	2574	66.3689	60	28.4083
‘22	840	66.6857	60	52.6277
‘23	321	66.5249	60	86.2266
Error	0	•	•	•

4. Shifting Towards Activeness – Concepts and strategies for Redes*ign Work*

In recent years technology development has been re-imagined from the perspective of how it could not only work as a tool or as a servant of human needs, but also how it could support and trigger more active living. Following from this various digital technologies has been designed to make people more active in their daily lives (including a wide range of personal informatics (PI) systems such as Runkeeper, Nike Fuelband, Fitbit, Jawbone UP etc.). Personal Informatics technologies refer to a class of software and hardware that collects information from the user, then processes and displays it in a way that improves the user’s self-understanding [14, 15, 22]. However, we have become accustomed to our lifestyles and our daily routine is a hard habit to break.

While most of the designs consider PI as a tool for self quantification, we think that there is a need to define new strong design concepts capable of not only informing digital design, but to find concepts guiding technology design in combination with the redesign of work, work activities and work environment. The basis for this design agenda should be to re-think our approach to designing workplaces, technologies and devices in

concert. In our research project which is run as a collaborative, transdisiplinary study between informatics, medicine and a school of architecture, we therefore plan to generate and define new concepts in support of active worklife living, followed by design work and empirical studies which will demonstrate and analyze the concept, generate designs for a real work setting and support us in the gathering of data to help further development.

As it was mentioned before there is a need of a method for conceptualizing design of information systems. In our research, we ground our work in concept-driven design methods as a way for advancing design [13,25]. In concept-driven design research, the purpose is to produce knowledge in the form of theoretical development through design. It is an exploratory investigation of established theories with the overall aim of improving and widening the range of theory and knowledge. Generally in this type of research, there is a deliberate intention to theorize the nature of interaction [25]. In a similar approach, Höök and Löwgren [13] introduced the notion of "strong concept", which is generative and carries the core design idea. They claim that strong concepts are design elements, but are, simultaneously, a part of the artifact. It is on an abstraction level which indicates use, practice and behavior over time [13].

Contextualizing this in relation to our research project, our goal is thus to formulate and design something that is a "strong concept", which corresponds to our ultimate goal – to design a personal informatics system and work environment which motivates and enable people to follow a more active daily life. This goal is driven by the medical research in our project which has pinpointed the health risks associated with obesity and has demonstrated that increasing daily movement might be an efficient approach to more healthy living (see [9], [19], [20], [21]).

In order to arrive at a good concept design, we cannot only subscribe to a technologically-driven approach. In our project, these perspectives are represented through a transdisiplinary research collaboration between informatics, medicine and architecture. More explicitly, we take a point of departure in medicine for understanding the relationship between obesity and everyday movement [19, 20, 21]. Further on, we see the architectural perspective as important for understanding the relationship between our built environment and how it governs everyday movements [4] (from floor plan layouts to building designs) and finally how an informatics approach to understanding people in relation to digital design can help in thinking about how to design good Personal Informatics feedback loops to record a person's everyday movements and to feed this data back to the person in an appropriate way.

5. Discussion

In this paper we have examined the historical reasons as to why people have become so inactive and became accustomed to prolong sitting over recent years. From the design of the first workstations to the development of interface agents, we have become used to adopting an inactive style of working that has been gradually imposed on us. Recently, however, there has been interest in making our work lives more active. In this section, we are going to examine some of these solutions and suggest how we might move forward from the current situation.

5.1 Contemporary Designs and Suggested Solutions

One of the early solutions was to accept the inactivity of one's working hours and then take one or two hours of exercise in the evening. This solution became so common that companies and organizations provided exercise breaks during work time and offered sports club memberships to their employees.

Later on, researchers, mostly from the medical field, disagreed with this solution and stated that activity should be reflected in everyday living. So, they tried to mix the two approaches by placing "treadmill desks" in

offices and work environments [19,20,21]. Although this design could be very effective in providing a platform for being more active during office working hours, it had its limitations. In short, this approach targets the problem at a superficial level. In keeping the tasks defining the work intact and only adding the treadmill under the desk the result is a multitasking worker who compensate for a work design which is still about inactivity and with the only difference that exercise is carried out in parallel to work, but not as a necessary part of work.

Other methods to motivate individuals to adopt active lifestyles include designing new technological devices such as PI systems or developing games or mobile applications [6]. Some of these technologies have relied on theories of persuasive technology whereas others have borrowed theories from behavioral studies. In general, most of these technologies are applicable at an individual level; they focus on individual motivation and these solutions have not been designed in relation to re-design of work and work places.

5.2 Moving Forward

The solution to the problem is deeper than just walking for one or two hours more every day. The key to this problem is to understand how designs have made us passive and, later on, how this passiveness has turned into habits and everyday routines. To tackle this problem we need to rethink and redesign the work environment. Although the design of a new Personal Informatics system will be considered as personal in its initial phases, this design should be considered from a more social and organizational viewpoint. Even pioneering researchers such as Shephard recognized the benefits of good lighting, cheerful music and cooler temperatures in the working environment [19]. While the changes that are normally written about in the literature are mostly about changes in the physical work environment, what we are suggesting is a rethink and redesign of workplaces and the environment as a whole for an active life whilst living digitally. By defining a single concept, we can examine the original problem holistically and then work out solutions using the three perspectives of informatics, architecture and medicine.

As was mentioned earlier, in order to reach a final design solution, we are going to examine our ideas at various stages. After the empirical study as reported in this paper, we will continue with a 2 months ethnographic study in two offices to track how work is performed in the current workplaces. Keeping in mind that we are aiming to re-designing work to bring activity into it, we are hoping to develop a new concept that could be the foundation of a new design.

6. Conclusion

In this paper we have described how today's sedentariness of our work lives has been guided by workplace design ideals formulated in the 70s. In response to this development we have in this paper suggested an alternative way forward. We have done so by pointing at concept-driven design research as a method and as an opportunity for moving forward. Further on, we have pointed at workplace opportunities, technical opportunities and workplace organizational opportunities for re-designing work in support of an active work life. For the road ahead we will critically examine the core problem of everyday movements holistically and then work out solutions in the intersection of architecture, medicine and informatics.

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